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Identification of Hydrocarbon Reservoir Distribution Using Seismic Attributes: RMS Amplitude and Sweetness in the Bani Field, South Sumatra Basin

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Abstract

The Bani Field is in the South Sumatra basin, which is considered to have potential hydrocarbon reserves. The seismic reflection method is one method that can be used to describe geological conditions. In addition, this method is also able to provide analyses related to the presence of hydrocarbon reserves in the form of oil and gas, where one of the analyses that can be used is seismic attributes. In this study, the seismic attributes used are the RMS Amplitude and the Sweetness attribute, both of which play a role in identifying subsurface structures and determining hydrocarbon indicators. This study was conducted to analyze the results of the application of the RMS amplitude attribute and the sweetness attribute in determining the distribution of hydrocarbon reservoirs and analyzing the results of the application of the variance attribute in detecting the fault structure of the Bani Field. From the results of the analysis using the RMS amplitude attribute, the Batu Raja Formation layer describes a good response with a yellow to reddish brown color scale with a value scale between 220,000 to 320,000 ms, while the Talang Akar Formation layer describes a good response with a value scale of 160,000 to 240,000 ms. The analysis using the sweetness attribute confirmed the interpretation of the RMS amplitude attribute, indicating the presence of hydrocarbons, as depicted by the sweet spot region. Meanwhile, the geometrical attribute analysis used, namely structural smoothing and variance attributes, helped map structures and identify faults.

Keywords: Envelope, Geological, Seismic Attributes, Subsurface Structures, Batu Raja Formation.

INTRODUCTION

Indonesia is an oil and gas producing country, where the primary energy source is oil and gas, which is often used for development (Putri & Adhi, 2022). Over time, oil and gas production has declined due to limitations and a lack of knowledge regarding new technologies used to interpret seismic data (Multi et al., 2023). Therefore, to find these energy sources, it is necessary to develop technologies that can help identify them (Østergaard et al., 2020). Reservoir rocks are rocks capable of storing and transmitting fluids. In general, hydrocarbon reservoir rocks can be divided into two types: sandstone and limestone or carbonate rocks (Hamza et al., 2023). Sandstone is a type of clastic sedimentary rock that functions as an aquifer or reservoir due to its relatively high porosity. Limestone is a type of carbonate rock, which has high porosity and is therefore capable of storing hydrocarbon reserves.

Based on the sedimentary basins spread across Indonesia, Indonesia has potential hydrocarbon reserves. However, sedimentary basins are not always considered hydrocarbon basins (Mirnanda et al., 2023). The Bani Field is located in South Sumatra and is an area with hydrocarbon potential (Zhu et al., 2021). The South Sumatra Basin covers an area of approximately with an average tertiary sediment thickness of 3.5 km (McNeill & Henstock, 2014). Geographically, the South Sumatra Basin is bounded by the Strait of Malaka, which stretches from the north to the northeast, the Tiga Puluh Mountains to the northwest, the Lampung Highlands to the southeast, and the foothills of the Barisan Mountains to the south to the southwest (Roos et al., 2014), as shown in Figure 1. The seismic reflection method is one method that can be used in oil and gas exploration activities and can also depict the geological conditions below the Earth's surface. This method utilizes the propagation properties of waves (Puspitasari, 2020). The seismic reflection method can provide analyses related to the existence of oil and gas reserves, one of which is analysis using seismic attributes. Selecting the right attributes for reservoir characterization will also provide a good geological picture.

Several researchers have utilized seismic attributes for case studies, such as the seismic attribute identification of hydrocarbon prospects in Nigeria, such as the Akos Field (Emujakporue & Enyenihi, 2020) and the analysis of hydrocarbon reservoir distribution, such as in Field X (Multi et al., 2023). In this study, the seismic attributes used were RMS Amplitude and Sweetness. The application of these seismic attributes in this study aims to identify subsurface structures and determine hydrocarbon indicators. The sweetness attribute is a supporting attribute used to confirm RMS amplitude results. This attribute has the advantage of identifying sweet spots, locations where hydrocarbons can be found (Koson et al., 2014). This research focuses on the application of RMS Amplitude and Sweetness attributes to predict hydrocarbon reservoir distribution and detect the structure of the Bani Field. Furthermore, this study aims to analyze and explore the application of these two attributes in determining reservoir distribution and identifying the structure of the Bani Field.

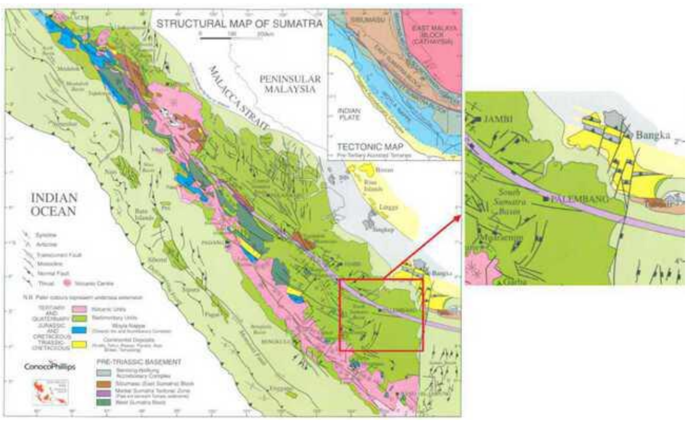

Figure 1. Map of South Sumatra Bounded by the Strait of Malaka

METHODS

This research was conducted at the Pusat Kajian Geofisika Reservoir, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Gadjah Mada (UGM), located in Umbulmartani, Ngemplak, Sleman, Yogyakarta, using Bani Field research data in the form of 3D Post-Stack Time Migration (PSTM) seismic data located in the South Sumatra Basin. This data consists of Inline (2003-2490) and Crossline (10041-10341) with a sample interval of 5 ms. In addition, this study used two wells, namely the BN-4 and BN-6 wells whose base maps can be seen in Figure 2.

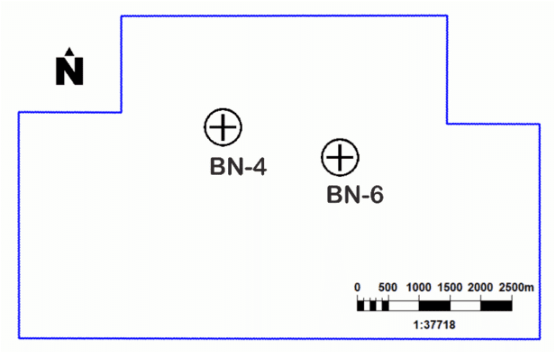

Figure 2. Base map of Bani Field

Several devices were used in the data processing process, including Schlumberger Petrel E&P Software Platform Version 2018, Hampson Russell Suite Version 10.3.2, and a Dell Precision PC with Intel XEON E5-2620, Nvidia Quadro K2200, 2.4 GHz, and 32GB of RAM on a 24-inch Dell monitor. Data processing in this study began with the input of seismic and well data. Wavelet extraction was then performed to perform the well-to-seismic tie process. Well-to-seismic tie is a crucial process in analyzing and interpreting seismic data and can assist in establishing relationships between the depth and time domains (Wu et al., 2022). This process was carried out until a good correlation was achieved. A correlation greater than 0.7 is considered good. The next step was horizon picking and fault picking, which were performed on all inline and xline sections. The horizon picking results were then used as input for the time structure map process, which would then be used in the seismic attribute process. The research flow diagram at Bani Field can be seen in Figure 3.

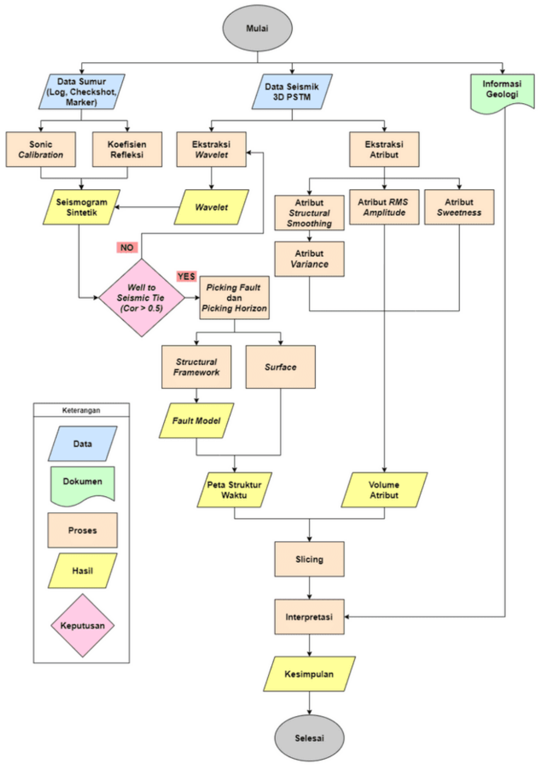

Figure 3. Flowchart

The seismic attributes used in this study are the RMS Amplitude and Sweetness attributes. These attributes are capable of identifying the structure and distribution of carbonate and sandstone reservoirs. This process is carried out in the volume attributes process, which can be seen in the seismic interpretation menu. Within the volume attributes option, there are various categories and attributes to choose from. In this study, the chosen category is structural methods, with the attributes used being structural smoothing and variance. Another category is basic attributes, with the attributes used being RMS amplitude and sweetness.

RESULTS AND DISCUSSION

The wavelet type used is Zero Phase. Zero Phase, or zero-phase wavelet, is a type of wavelet with energy centered at t = 0 and is used for the well-to-seismic tie process. This process was carried out on wells BN-4 and BN-6. This process can be seen in Figure 4 and Figure 5.

In the BN-4 well, the correlation value obtained was 0.702. The BRF marker is located on the seismic peak trace with a time domain of approximately 1240 ms and a depth domain of approximately 1415 ft, then the TAF marker is located on the seismic trough trace with a time domain of approximately 1260 ms and a depth domain of approximately 1435 ft, while the MFS-9 marker is located on the seismic peak trace with a time domain of approximately 1355 ms and a depth domain of approximately 1565 ft.

In the BN-6 well, the correlation value obtained was 0.641. The BRF marker is located on the seismic peak trace with a time domain of approximately 1268 ms and a depth domain of approximately 1380 ft, then the TAF marker is located on the seismic trough trace with a time domain of approximately 1280 ms and a depth domain of approximately 1420 ft, while the MFS-9 marker is located on the seismic peak trace with a time domain of approximately 1370 ms and a depth domain of approximately 1610 ft. This process produces correlation of the BN-4 well and the BN-6 well shown in Table 1.

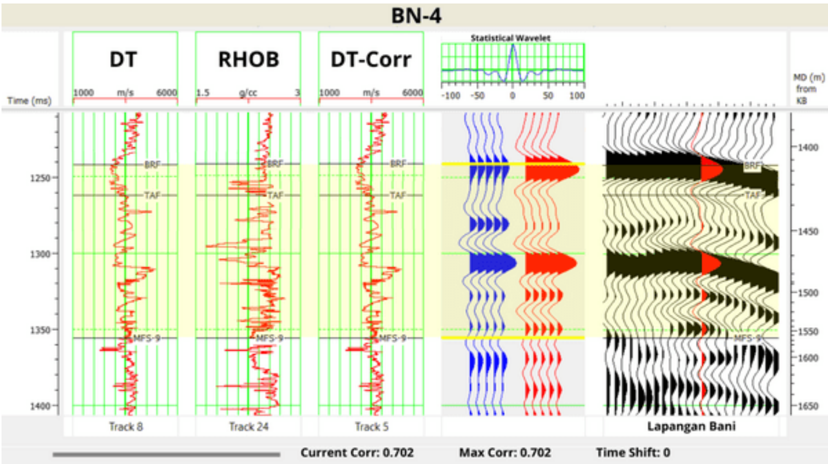

Figure 4. Well to seismic tie results on the BN-4 well

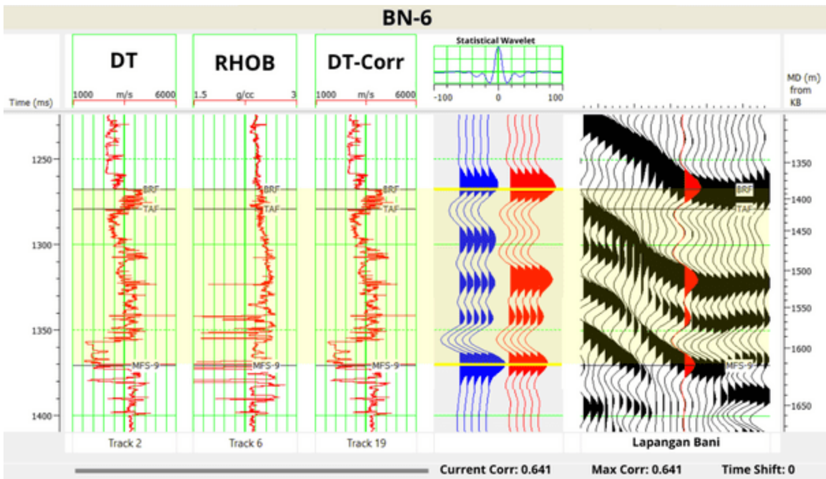

Figure 5. Well to seismic tie results on the BN-6 well

Table 1. Well to seismic tie results on the BN-6 well

Name of the Well	Formation			Correlation Value
	BRF	TAF	MFS-9	
BN-4	Peak	Trough	Peak	0.702
BN-6	Peak	Trough	Peak	0.641

The two wells that underwent well-to-seismic tie showed similar consistency for each formation. This is advantageous because it will facilitate the horizon and fault picking processes (Safari et al., 2023). The results of this picking process will then be used to create a time structure map. The results can be seen in Figure 6. The results in Figure 6 illustrate that there is a fault extending from the south to the northeast, appearing as a white line with large amplitude changes. The amplitude values range from -1260 ms to -1160 ms, from yellow to red, representing highland areas. Meanwhile, the amplitude ranges from -1270 ms to -1460 ms, from light green to purple, represent lowland areas (Zhong et al., 2022).

RMS Attribute Analysis

To obtain reservoir information, the RMS Amplitude attribute can be used as a good indicator in identifying reservoir anomalies based on their amplitude (Aviani et al., 2022). The amplitude attribute is very important because it can eliminate the influence of the wavelet phase of seismic amplitude and distortion from reflection polarity, thus making the contrast of bright spots more easily visible (Verma et al., 2022). Figure 7 and Figure 8 illustrate the slicing results of the RMS amplitude attribute for the BRF layer and the TAF layer where the high RMS amplitude value is depicted as a zone with hydrocarbon potential shown on a yellow to reddish brown color scale with a value scale in the BRF layer between 220,000 to 320,000 ms while in the TAF layer the value scale is 160,000 to 240,000 ms and the low RMS amplitude value is on a purple to yellowish green color scale with a value scale in the BRF layer between 0 to 220,000 ms while in the TAF layer between 0 to 150,000 ms.

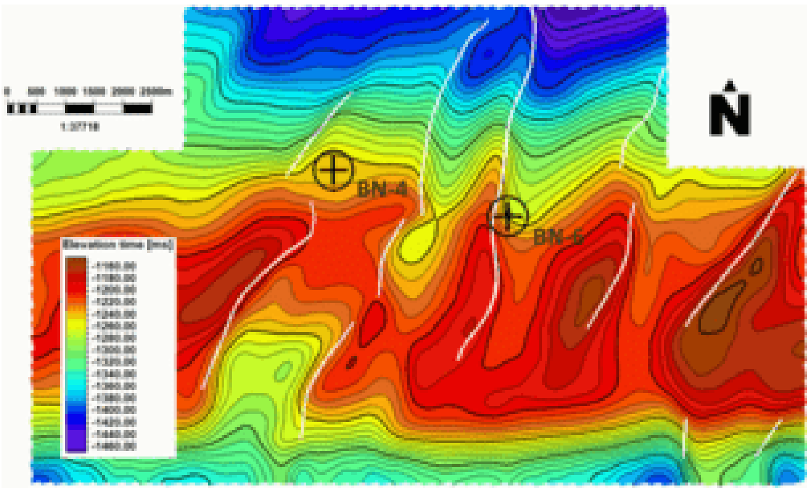

Figure 6. Time structure map of BRF formation

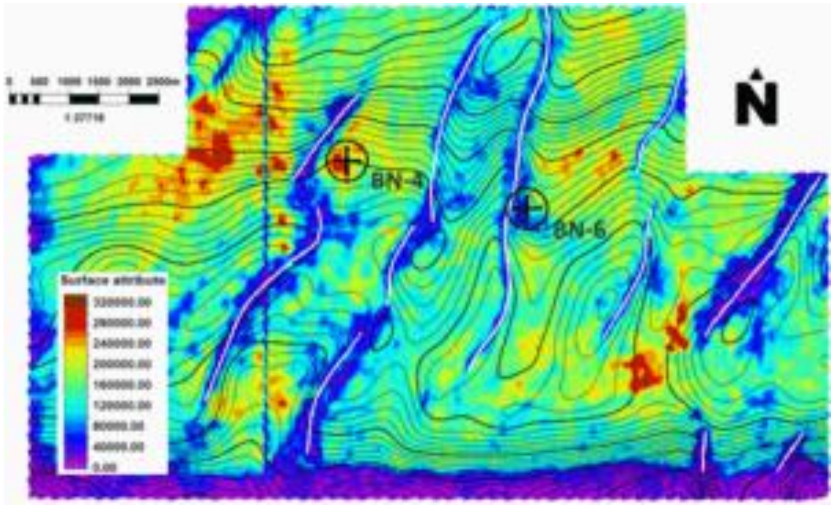

Figure 7. RMS amplitude attribute slicing map of the BRF formation

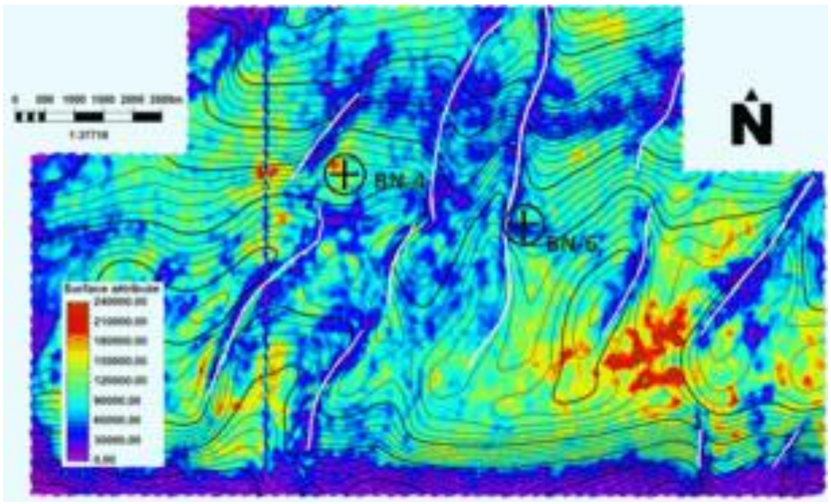

Figure 8. RMS amplitude attribute slicing map on the TAF formation

Sweetness Attribute Analysis

The sweetness attribute is a supporting attribute used to confirm the RMS amplitude results, where this sweetness attribute has the advantage of identifying sweet spots as places where hydrocarbons can be found (Koson et al., 2014). The sweet spot is found in the BRF layer which is suspected to be a source of carbonate rock reservoirs which is reinforced by the explanation of Oktarisma et al. (2022), which explains that carbonate rocks are a reservoir source in the BRF and the TAF layer is a source of sandstone reservoirs which is reinforced by the explanation of (Rosalline et al., 2023), which states that the dominant source of hydrocarbons in the South Sumatra basin is the TAF sandstone.

Figure 9 and Figure 10 are the results of the sweetness attribute slicing map carried out on the BRF layer and the TAF layer where the results of the sweetness attribute application confirm the results of the RMS attribute which indicates the presence of hydrocarbons. High sweetness values describe the sweets spot area shown on a greenish yellow to red color scale with a value scale in the BRF layer of 58500 ms to 72000 ms while in the TAF layer the value scale is 49500 ms to 63000 ms (Glaser et al., 2013).

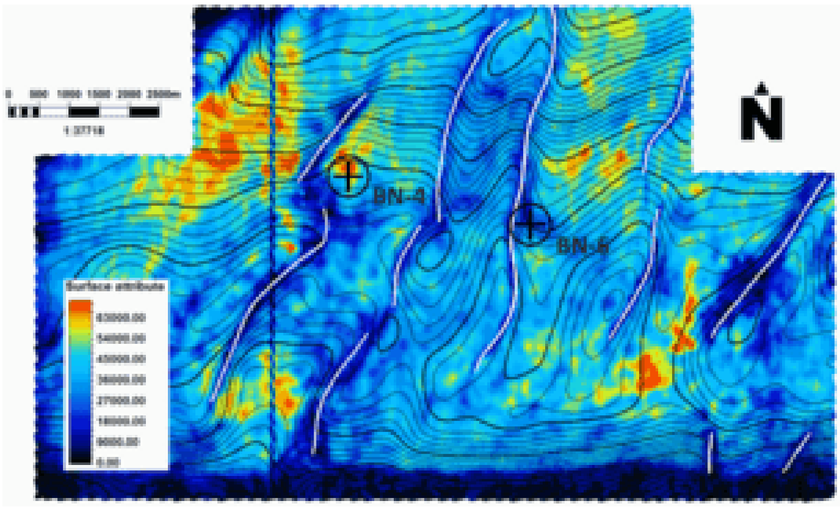

Figure 9. Slicing map of sweetness attributes in the BRF formation

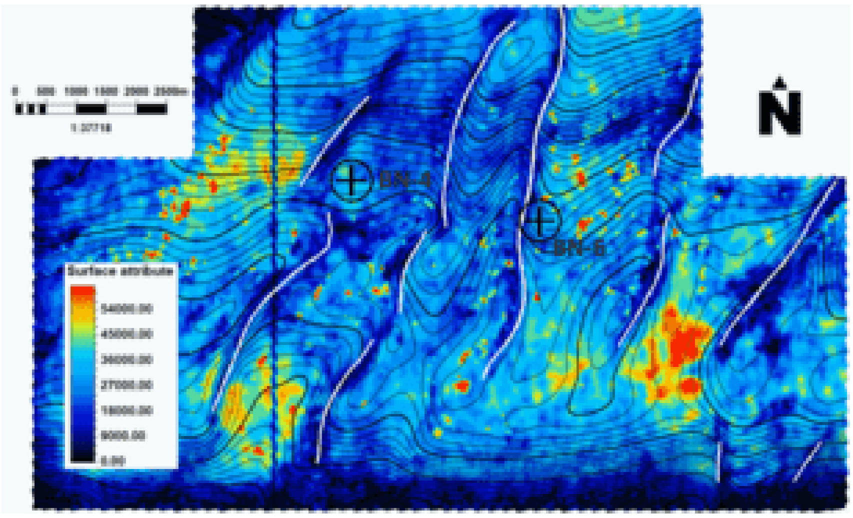

Figure 10. Slicing map of sweetness attributes in the TAF formation

Attribute Variance Analysis

Variance, also known as edge detection, is a highly effective attribute for identifying fault delineations, sequence boundaries, channels, fractures, and several other geological features. Before applying the variance attribute, smoothing is essential to reduce noise (Cleveland et al., 2013). The variance attribute can describe discontinuities in seismic data related to faults in vertical seismic profiles and horizon slices (Koson et al., 2014).

The variance attribute itself has the disadvantage that the faults in the seismic image are presented in a scattered and random manner, indicating that this attribute only provides information about the presence and location of faults but cannot clearly describe their orientation. The results of the variance attribute surface in the BRF and TAF layers can be seen in Figures 11 and 12.

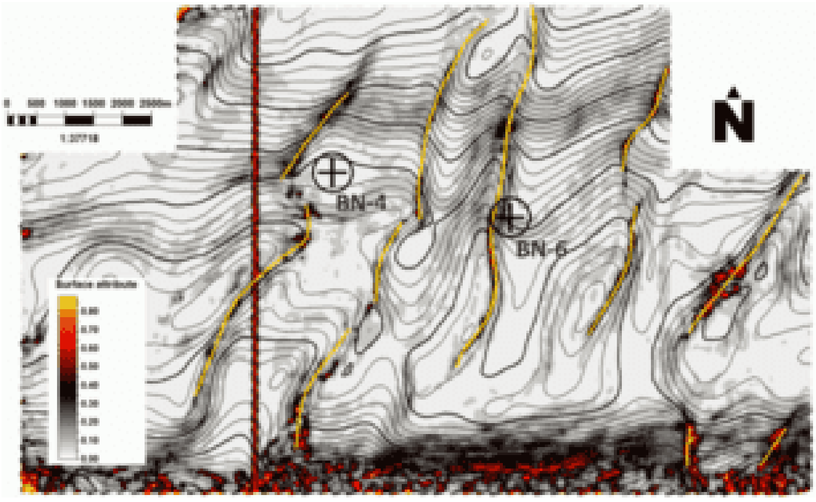

Figure 11. Variance attribute slicing map on the BRF formation

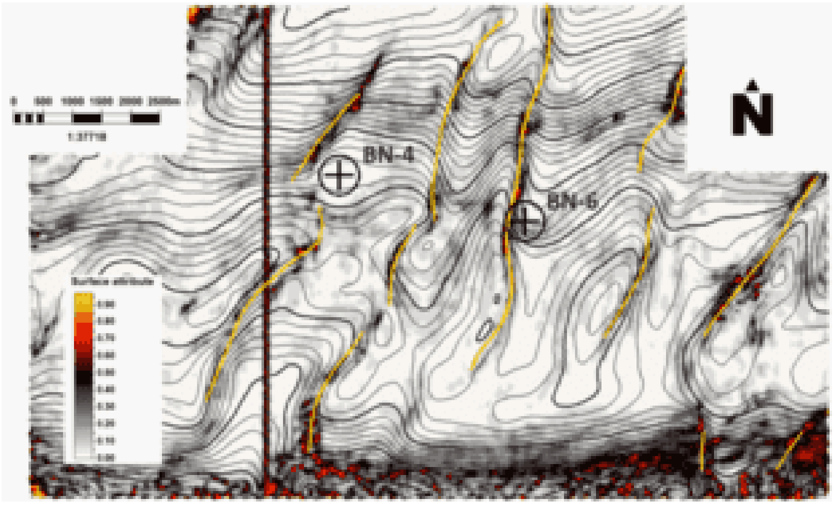

Figure 12. Variance attribute slicing map on TAF formation

Interpretation

The interpretation results in this study are based on the use of the attributes used. The results of the application of the sweetness attribute confirm the results of the RMS amplitude attribute. The sweetness attribute can identify where hydrocarbons can be found, which is characterized by the presence of sweet spots. The interpretation results from the Bani Field can be seen in Figure 13 and Figure 14 in the form of an overlay of both attributes, namely the RMS amplitude and sweetness attributes. The light green area is the area with the interpretation results of the RMS amplitude attribute, while the pink area is the area with the interpretation results of the sweetness attribute, and the brown area is the area resulting from the overlay between the RMS amplitude and sweetness attributes, which are suspected to have superior hydrocarbon prospects (Li et al., 2019).

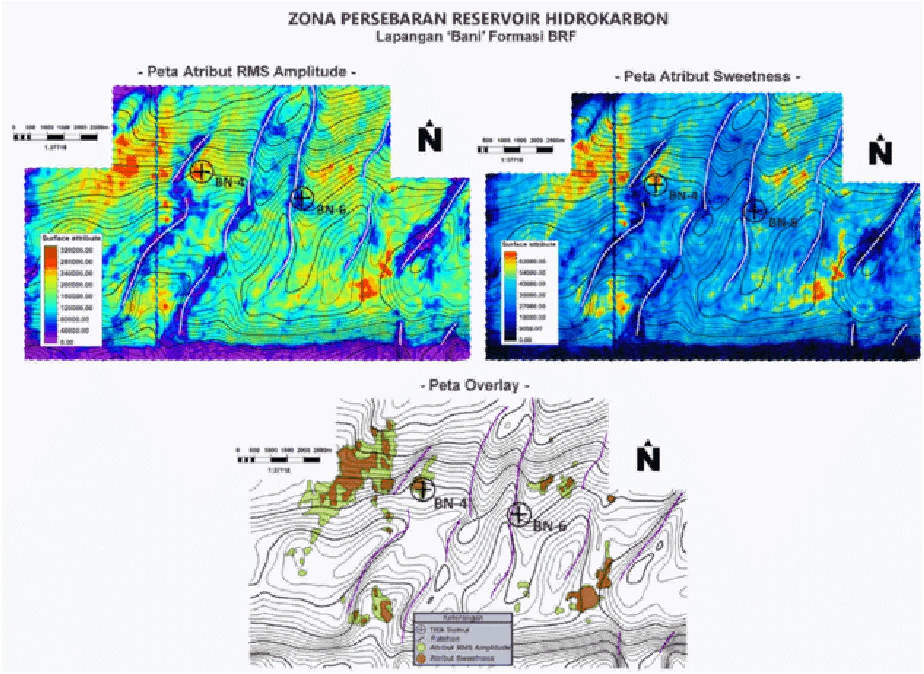

Figure 13. Map of hydrocarbon reservoir distribution zones in the BRF formation

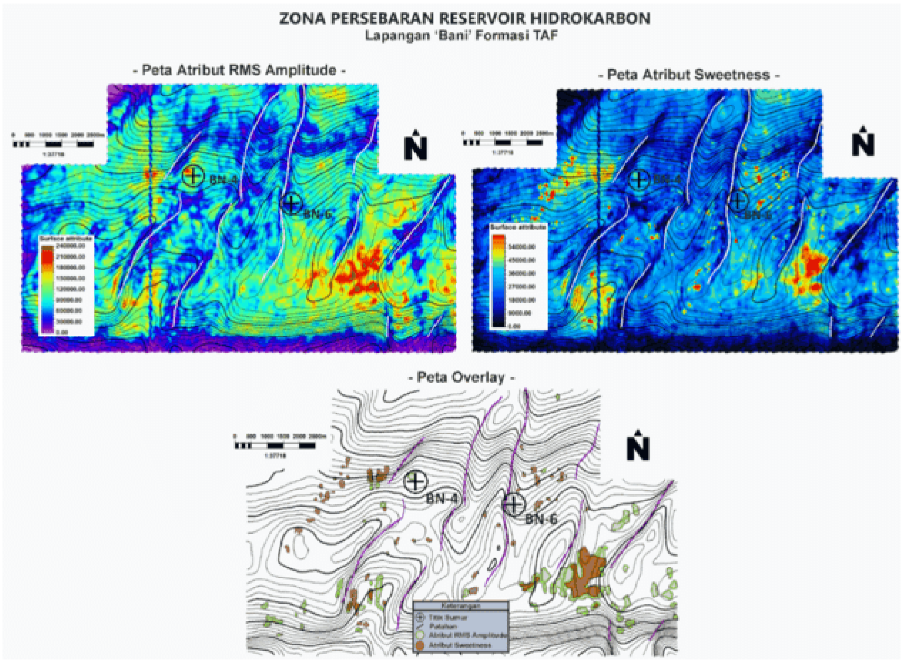

Figure 14. Map of hydrocarbon reservoir distribution zones in the TAF formation

CONCLUSION

Based on the results of research and data interpretation that has been done in the Bani Field, it can be concluded that with the RMS amplitude attribute obtained bright-spot area suspected of accumulating hydrocarbons around the BN-4 well with a color scale from yellow to brownish red in the Baturaja Formation and TAF Formation, however in the BN-6 well there is no bright-spot or sweet-spot indicator that is suspected of having no hydrocarbon reserves in the well. In addition, the sweetness attribute clearly confirms and justifies the results of the interpretation with the RMS attribute which indicates the presence of hydrocarbons around the BN-4 well with a color scale from greenish yellow to red in the Baturaja Formation, but in the Talang Akar Formation depicts a hydrocarbon accumulation that tends to be small. Then the application of the variance attribute in this study clearly shows the presence of discontinuities suspected of being faults that cut vertically on the seismic cross section of the Bani Field.

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